

Removal of H_2S On Oxidized Iron

N.J. Kertamus

Babcock & Wilcox Research Center

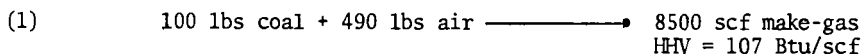
1.0 INTRODUCTION

This paper summarizes tests made by the Babcock and Wilcox Company to remove H_2S from a fuel gas generated from the gasification of coal with air. Reported specifically are:

- (a) Results from bench top tests aimed at yielding information necessary for design purposes.
- (b) A descriptive mechanism that explains H_2S removal and regeneration.
- (c) A hardware design based on these results.

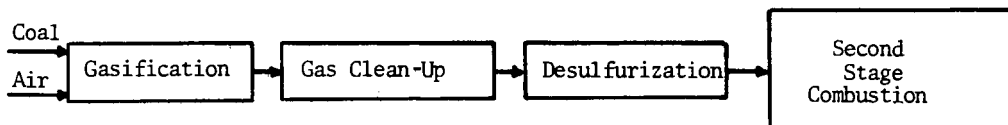
2.0 BACKGROUND

Air-blown gasification of coal in an entrainment or suspension type gasifier represents combustion with substoichiometric air to generate a product gas that contains chemical heat in the form of CO and H_2 diluted with N_2 . This so-called 'make-gas', after gas clean-up, is burned in a second stage combustion device to generate electric power. For example, gasification of a typical bituminous coal with 50 percent stoichiometric air is represented by



Sulfur present in the coal winds up largely as reactive H_2S in the make-gas. The concentration depends on the sulfur concentration in the parent coal. Figure 2.1 illustrates the approximate H_2S concentration that would be obtained in air-blown gasification of a typical bituminous coal as a function of heating value of the gas produced and the percent sulfur in the coal being gasified. The H_2S levels illustrated in Figure 2.1 assume complete gasification of coal and no char product.

For electric power production the process concept is:



Justification for air-blown gasification of coal in terms of electric power production stems from the facts that:

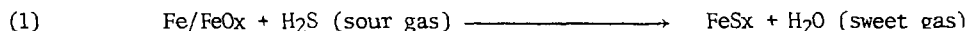
- (a) Sulfur is concentrated in the make-gas as H_2S .
- (b) H_2S is more reactive than SO_2 .
- (c) After gas clean-up and desulfurization, the make-gas represents a high quality fuel gas that could have application as a gas turbine fuel.

3.0 APPROACH - BABCOCK AND WILCOX

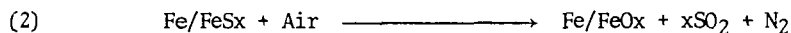
The approach taken by Babcock and Wilcox is to remove H_2S from the make-gas by reaction with iron oxide at a comparatively high temperature. The objective is to minimize the amount of cooling needed between the gasifier and the second stage combustion device.

The use of iron oxide to remove H_2S is not a new or unique approach. Historically hydrated iron oxide has been used for decades in oxide boxes to remove H_2S from coke oven gas. At the present time, work is being done by the Bureau of Mines on a concept that removes H_2S with a sintered material made from iron oxide and fly ash. Our concept is different in as much that we start out with carbon steel and generate, on the surface of the carbon steel, an $FeOx$ scale that is used as the desulfurization agent. In terms of the mechanism of sulfur removal, it is likely that both the Bureau of Mines' and our concepts are alike.

Briefly, the concept removes H_2S by:



At some point in time all of the available iron oxide scale is converted to the sulfide scale, At that point the system is regenerated with air, as follows:



The overall process accomplishes two things:

- (1) It concentrates sulfur at 0.4% volume percent in the make-gas to 10-13 volume percent SO_2 in the regenerant gas.
- (2) It provides SO_2 in the rich regenerant gas that is either (a) oxidized and recovered as H_2SO_4 or (b) reduced to elemental sulfur.

4.0 OBJECTIVES

In our earlier work reported previously, a one-foot diameter gasifier was coupled to an iron grid desulfurization system. The desulfurization system was operated at temperatures in excess of 1200F. Because material problems exist at these temperatures, our experiments emphasized desulfurization at temperatures from 1200 down to 675F.

A second objective was aimed at understanding, in a descriptive sense, the reactions that occur during desulfurization and regeneration on the iron surface.

Our final objective was to design a sulfur removal system that could be coupled to a large scale gasifier.

5.0 EQUIPMENT AND PROCEDURE

Figure 5.1 shows a sketch of the test system. The reaction vessel was a 1-inch ID aluminum tube filled on the bottom side of the bed with inert mullite chips. The chips served to support the test bed and to preheat the make-gas to the desired temperature.

The modified Reich idiometric technique was used to measure H₂S. This technique does not differentiate between H₂S or SO₂; total sulfur is measured. The SO₂ produced in the air regeneration was measured by an ultraviolet detector developed by the Babcock and Wilcox Company.

The synthetic make-gas composition was:

<u>Constituent</u>	<u>Percent (Volume)</u>	
CH ₄	1.0	
CO	12.0	
H ₂	8.0	HHV = 74 BTU
CO ₂	8.0	SCF
H ₂ O	6.0	
H ₂ S	1.0	
N ₂	Bal.	

Each test was started by heating the reactor to the desired temperature with a nitrogen purge. On attaining test temperature, make-gas was started through the unit; this defined zero time. The H₂S concentration of the desulfurized gas was continuously monitored and the absorption bed was considered saturated when the desulfurized make gas reached 0.10 percent H₂S. At that point the bed was regenerated with air at the same conditions of temperature and flow rate as the sulfur absorption.

The sulfur absorbent was designated as low hardness, perma-abrasive, plain carbon-steel shot with the following analysis:

Total carbon	2.5	-	2.8 wt.%	Phosphorous	0.02 - 0.04 wt.%
Graphite carbon	0.5	-	1.25 wt.%	Hardness	32 - 40 (Rockwell C)
Silicon	1.0	-	1.4 wt.%		

6.0 RESULTS

6.1 Desulfurization Results

Figure 6.1 is a plot of the sulfur concentration of the desulfurized make-gas versus time or volume of make-gas passed through the bed. The shape of the curve is typical of all results obtained at temperatures less than 1000F down to the minimum temperature considered, or 675F. In these tests, initially, a sharp sulfur concentration spike occurred. After the sulfur concentration spike the sulfur level dropped to a very low value, then increased with time or volume of make-gas treated. The increasing sulfur concentration was due to the depletion of available iron oxide scale. Arbitrarily, a test was terminated after the sulfur level increased to 0.1 percent, or when the make-gas at that point was 90 percent desulfurized.

The average sulfur concentration of the make-gas was determined by integrating the area under the curve to the 0.1 percent end point. For the case illustrated in Figure 6.1 the average sulfur concentration was 0.05 percent. Although the average sulfur concentration is relatively low (0.05 percent), because of the concentration spike, the instantaneous level at the top of the spike is higher 0.14 percent. What this means is that in the design of a workable desulfurization device, a number of beds staggered with respect to the regeneration cycle should give a product gas that approaches the average sulfur value, or for 675F operation a gas of 0.05 percent sulfur.

In general the magnitude of the concentration spike decreased as the temperature was raised to 1000F. Operation at 1000F and higher eliminated the concentration spike. Figure 6.2 illustrates the sulfur level of make-gas as a function of operating temperature. These results represent:

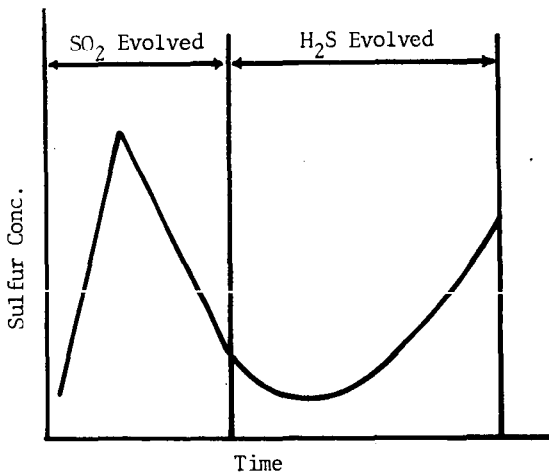
- (a) Operation at space velocities from 2000 to 2500 volumes of gas per volume of bed per hour.
- (b) An end point of 0.1 percent sulfur.

At the same conditions, Figure 6.3 illustrates the sulfur pick-up on a well conditioned surface, namely, the volume of H_2S removed or reacted with the iron oxide scale at 60F and 14.7 psig, based on $100Ft^2$ of iron surface initially charged to the desulfurization unit. The results represented in Figure 6.3 were also determined using an end point of 0.1 percent sulfur for the treated make-gas and space velocities of 2000-2500 vol. gas per vol. bed per hour.

6.2 Descriptive Mechanism

Because of the presence of the unwanted sulfur concentration spike observed during sulfur absorption at temperatures less than 1000F, a series of short tests were made with the objective of defining, in a descriptive sense, the important reactions that govern sulfur removal and regeneration. Some of the pertinent results were:

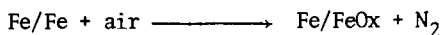
1. The spike results from SO_2 evolution and not H_2S , even though only H_2S is fed to the bed. This is illustrated below.



- 2 The regeneration temperature determines whether the spike will occur. For example, if regeneration is conducted at a temperature greater than 1000F and the bed is cooled to say 675F for desulfurization, no spike results.
- 3 Pretreating a regeneration bed (low temp) with CO or H₂ eliminates the spike. If, however, the reduced bed is subsequently purged with air SO₂ is evolved.
- 4 Heating and cycling a fresh surface between make-gas and air, in short tests, does not develop a thick scale necessary for desulfurization.
- 5 For short tests the surface is developed by cycling at temperatures around 1450F.
- 6 A high concentration of steam in the make-gas decreases the efficiency of sulfur removal.

The following reactions explain the observed results. In addition thermodynamic calculations suggest these reactions are feasible at temperatures of our system.

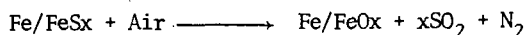
1. Heating in air at temperatures to 1400F develops a thin surface layer of FeOx. Surface not activated.



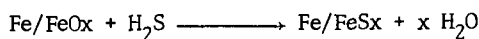
2. Activation 1450F



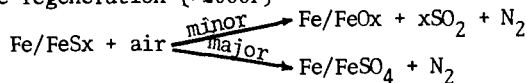
3. High temperature regeneration (>1000F)



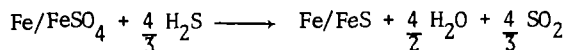
4. Equilibrium sulfur removal



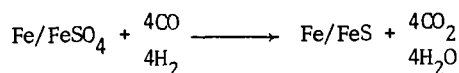
5. Low temperature regeneration (<1000F)



6. Sulfur concentration spike



7. Prereduction (800F)



7.0 HARDWARE CONCEPT

The hardware concept for sulfur removal and regeneration should:

- (a) Have a large number of compartments at various stages of regeneration to give an average H_2S concentration relatively independent of the regeneration cycle.
- (b) Give a maximum concentration of SO_2 in the regenerant gas.

The hardware that has been designed uses a number of compartments for sulfur removal and the so-called counter-current principle for air regeneration. The desulfurizer uses a modified regenerative type air heater and is referred to as the "regenerative desulfurizer." Figure 7.1 illustrates this concept. The cylindrical unit is segmented into 16 compartments. Each compartment is filled with carbon-steel plates oriented longitudinally with the gas flow. Within each compartment the longitudinally oriented carbon-steel plates will contain about 100 square feet of surface of the carbon-steel plates. The vessel itself will be constructed from high alloy steel.

7.1 Sulfur Removal

Sour H_2S containing make-gas from the gasifier passes downward through 13 of the 16 compartments where desulfurization occurs on the surface of the carbon-steel plates that fill each compartment. The sweet make-gas issues from the base of the unit and is routed to a second stage combustion device.

7.2 Regeneration

The sulfided iron surface is converted back to the oxide in 3 of the 16 compartments shaded in the sketch. The regeneration air passes in and upward in the first compartment to a cross-over, then downward for a second pass, and upward for a third and final pass. At two revolutions per hour each of the 16 compartments is regenerated twice per hour.

Air at 21 percent O_2 enters the first regeneration compartment where it contacts a partially regenerated surface accomplished in the second and third pass down stream. At the end of the first pass the O_2 concentration is well below 21 percent. During the second pass, the O_2 concentration is further reduced while SO_2 increases. Purging the third (most FeS fouled) compartment with a gas containing a minimum concentration of O_2 and a maximum concentration of SO_2 insures a maximum SO_2 concentration of the final regenerant gas. The regenerant gas should contain from 10 to 13 percent SO_2 and up to 4 percent O_2 and nitrogen.

In practice SO_2 in the rich regenerant gas can be:

- (a) oxidized and recovered as sulfuric acid
- (b) reduced to elemental sulfur.

We believe the better approach is reduction and recovery as elemental sulfur. In coal gasification systems, two reductants are available, i.e., make-gas itself ($CO + H_2$) or char. Currently, B&W is actively studying SO_2 reduction using char that will be available from gasification of coal.

8.0 CONCLUSIONS

After a thick layer of iron oxide or sulfide scale is generated on the surface of plain carbon steel, the scale effectively removes more than 95 percent of the sulfur in a make-gas generated from air gasification of coal. The process works at temperatures as low as 675F; however, because of regeneration, operation at temperatures in excess of 1000F is desirable.

Conservative operation of the process should yield SO₂ values of 0.5 - 0.6 lbs per million Btu input, or a value well within the EPA guidelines.

The concept has been demonstrated in bench scale equipment and a hardware design has been developed. The workability of the concept on a large scale, however, has yet to be demonstrated.

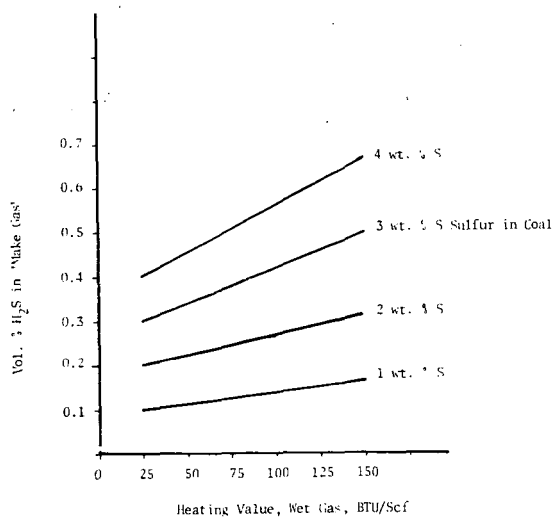


FIGURE 2.1 H_2S CONC. VS. HEATING VALUE COMPLETE GASIFICATION

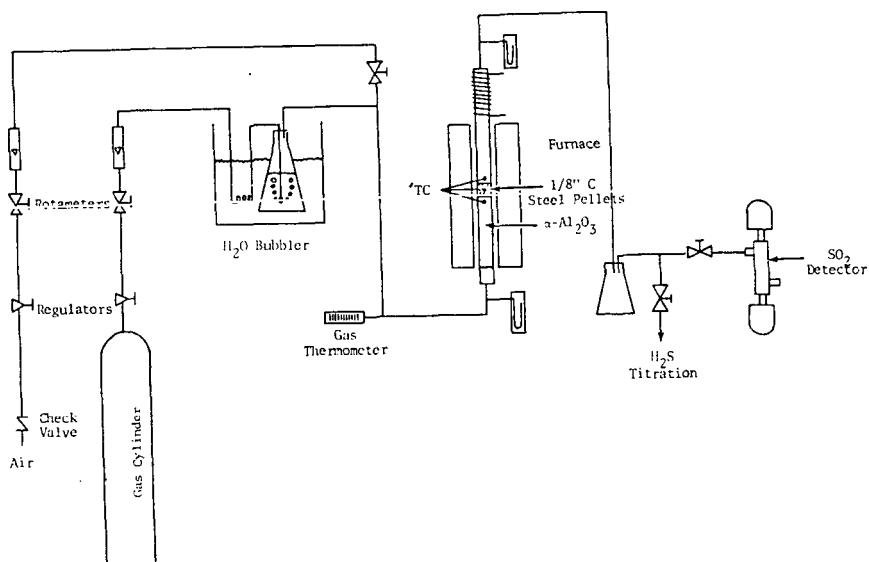


FIGURE 5.1 TEST EQUIPMENT

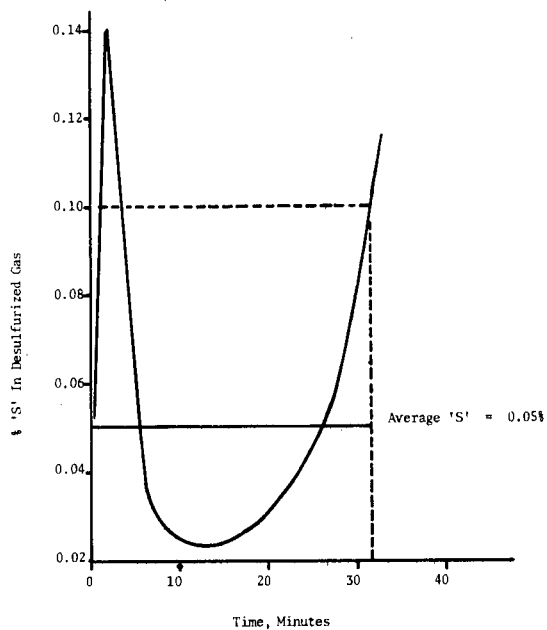


FIGURE 6.1 SULFUR CONC. DESULFURIZED GAS

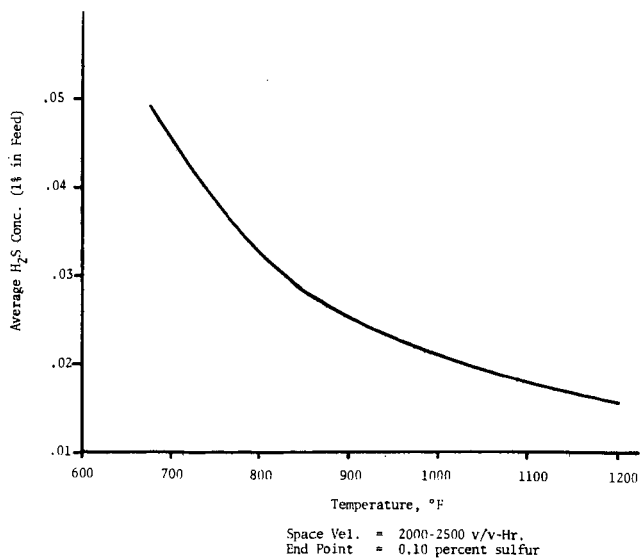


FIGURE 6.2 SULFUR CONC. VS. TEMPERATURE

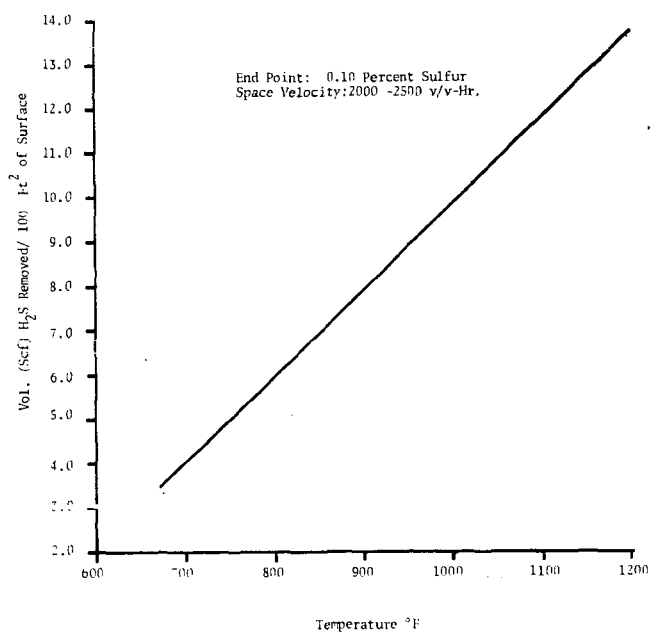


FIGURE 6.3 SULFUR PICK-UP

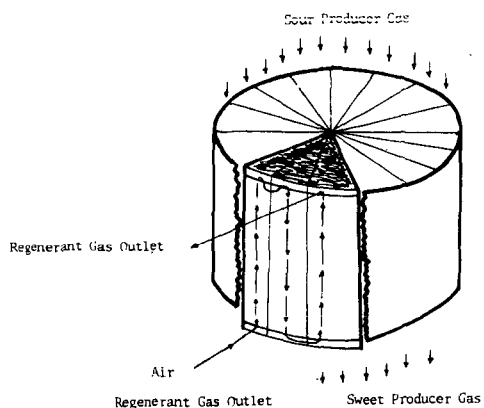


FIGURE 7.1 REGENERATIVE DESULFURIZER

BENFIELD PROCESSES FOR SNG OR FUEL GAS PURIFICATION. D. H. McCrea and H. E. Benson. The Benfield Corporation, 666 Washington Road, Pittsburgh, Pa. 15222

Processes to produce Substitute Natural Gas or fuel gas from liquid hydrocarbons or coal reject excess carbon as CO_2 . In addition, a portion of any sulfur initially in the feed appears in the gas, principally as H_2S . In producing SNG, both CO_2 and sulfur compounds, if present, must be removed. However, it is often advantageous to remove the bulk of sulfur compounds while minimizing CO_2 removal when producing gas for turbine or boiler fuel. While purification methods have not received the coverage of gasification and methanation techniques, purification is an essential step in all gasification processes that can significantly affect overall cost and reliability. This paper discusses the use of Benfield potassium carbonate processes for SNG or fuel gas purification. Process chemistry is described as are means of selective absorption and concentration of H_2S . Benfield systems designed for use in producing SNG from naphtha, from heavier hydrocarbons, and from coal are outlined and their investment and operating costs given. Systems for purification of low BTU fuels are also discussed. Operating data from commercial units are presented.

SYNTHETIC FUEL GAS PURIFICATION

BY THE SELEXOL[®] PROCESS

by John W. Sweny
Allied Chemical Corporation

Processes for production of fuel gases from coal and petroleum come at a time when stringent requirements on sulfur emissions are being imposed. Indeed, part of the demand for these gaseous fuels stems from these requirements, because gases are relatively easy to desulfurize compared to liquids and solids.

The main contaminant to be dealt with is H_2S . After removal H_2S is converted to elemental sulfur, which is harmless and even sometimes profitable. Claus plants get first consideration for H_2S conversion because they are well-known and economical. For high conversion and economy, Claus plants require a feed that is rather rich in H_2S . A feed containing 20% H_2S is considered a satisfactory Claus feed.

Concentrations as high as 20% are difficult to reach when treating synthetic fuel gases. In the production of high-Btu gas from coal, for example, the intermediate gas before methanation usually contains about 0.7 vol % H_2S and 30% CO_2 . If both H_2S and CO_2 are removed to low levels with a non-selective solvent, the

[®]SELEXOL is a Registered Trademark of Allied Chemical Corporation.

Claus gas will be too lean for processing, about 2-3% in H_2S . The low-Btu gases would yield richer Claus feeds than this, but they too will yield gases too lean for economy and high conversion. A typical gas, for example, contains 0.7% H_2S and 8% CO_2 , which would, with a non-selective solvent, yield a Claus gas containing only about 8-10% H_2S .

High Selectivity Required

Thus there is a need for highly selective solvents. Several selective solvents of both physical and chemical type are available but few have enough selectivity to remove H_2S to the very high degree required while holding CO_2 absorption down to acceptable levels. H_2S content of product gases must usually be 4 ppmv or less. If the raw gas contains 0.7% or 7000 ppm, the degree of removal is then at least 99.94%, which may be higher after allowance for shrinkage due to CO_2 absorption. If the Claus gas is to contain 20% H_2S , the amount of CO_2 absorbed can only be four times that of the H_2S , or 2.8% of the original feed gas. Thus, if the original feed gas contained 30% CO_2 , its degree of removal cannot exceed 9.35%; if 8%, 35.0%. The task is then to remove 99.94% of the H_2S while leaving 90.7% of the CO_2 untouched in one example and 65% untouched

in the other.

Chemical solvents can remove acid gases with great efficiency and economy if the concentrations are low, but they cannot, as far as I know, achieve the kind of selectivity for H_2S required for Claus processing of synthetic fuel gases. The 4 commercially available physical solvents, including SELEXOL Solvent, can however achieve the required selectivity. The physical solvents, moreover, can remove certain other sulfur compounds which are non-acidic: COS, mercaptans, organic sulfides, and thiophenes. These must be converted to H_2S before they can be absorbed by chemical solvents. Some physical solvents, including SELEXOL, can simultaneously remove water to the standard specifications for pipeline gas, thus eliminating the need for auxiliary drying units.

Selective Absorption

Absorption systems forming ideal solutions show selectivities in proportion to pure-component vapor pressures, in accordance with Raoult's Law. For example, the vapor pressure of CO_2 at $60^\circ F$ is 752 psia; for H_2S , 230 psia. If the vapor and the liquid form ideal solutions, the relative solubility or selectivity will be $752/230 =$

3.27; that is, under equivalent conditions, H_2S will have 3.27 times the solubility that CO_2 will.

Good selective agents, however, will form non-ideal solutions in which both solutes are solvated, H_2S being more strongly affected than CO_2 . The selectivity for these in SELEXOL Solvent at $60^\circ F$ and 1000 psia is 9.16, about 2.8 times what it would be in an ideal solution. This nine-fold value for selectivity is not constant; it will vary somewhat with temperature, pressure, and composition of the system. Although there are large negative deviations from Raoult's Law, the solvation does not prevent easy desorption. Heats of desorption of H_2S and CO_2 from SELEXOL Solvent are only about $1/4$ of those found with chemical solvents.

Both the vapor phase, since it is under high pressure, and the liquid phase are very non-ideal. Thus many experimental VLE points are required for SELEXOL Solvent. These have been difficult to correlate over the wide ranges of composition, temperature, and pressure encountered in gas purification plants.

The selectivity inherent in the solvent, as expressed by a ratio of K-values, will not be realized unless the

solvent rate is kept low. If the solvent rate is near the minimum required for complete removal of H_2S or COS (i.e., if the Kremser absorption factor is somewhere between 1.0 and 1.5) it will be well below the minimum required for CO_2 removal. In the examples used, only about 15 to 25% of the CO_2 present may be removed, no matter how many contacts are provided in the absorber. CO_2 will be quickly absorbed at the top of the absorber, reaching saturation in the first contact. As the solvent passes downward, absorbing H_2S , through the other contacts, no more CO_2 will be absorbed. In this way a large fraction of the H_2S can be absorbed while holding the absorption of CO_2 to a low level. Absorbers used for selective absorption will therefore have many contacts and low solvent circulation rates, in contrast to the bulk absorbers which will have relatively few contacts and high circulation rates.

The quantity of H_2S in gas from coal and crude oil is low, generally less than 1%. The CO_2 concentration, on the other hand, can be high, as high as 30%. This means that the temperature profile down through the absorber will be dominated by CO_2 rather than by the key component, H_2S .

The high partial pressure of CO_2 will cause substantial absorption to take place at the top, causing a quick rise in temperature at the top contact, followed by a slower rise down through the other contacts as H_2S and smaller quantities of CO_2 are absorbed.

The temperature profile in selective absorption will then normally be irregular, and the assumption of straight-line or equal-percentage variation down the tower cannot be made. At low solvent rates, moreover, the feed gas may further change the profile if the feed temperature is markedly different from absorber temperature.

K-values are sensitive to temperature; for example, the K-values for H_2S in SELEXOL Solvent in methane systems at 1000 psia increase about 15% for each 10°F rise in temperature. Thus, solubility will more than double between a drop from 100°F to 40°F . The temperature profile to be expected must therefore be taken into account in making a satisfactory design, and K-values must be available to permit designing as closely as possible to the temperatures which will prevail down through the tower.

The complete cycle of course, includes flashing, stripping, and heat exchange, which are carried out at a completely different set of pressures, temperatures, and compositions from that for absorption. The K-data required to calculate the results of these operations need to be predicted accurately over a wide range of conditions, which puts a strain on experimental VLE determinations and methods of correlation. Development of reliable K-data is probably the most important single factor in the success of a physical solvent, and offers the most difficult challenge in putting such processes into practice.

High-Btu Synthetic Gas

The SELEXOL process will be used in one of the new coal-gasification processes, the Bi-Gas process originated by the Bituminous Coal Research Corporation and sponsored by OCR and AGA. A demonstration plant is now planned for construction at Homer City, Pa.

To optimize methanation, some coal gasification processes require gas purification at three stages: removal of H_2S from gasifier effluent after CO-shift conversion and two stages of CO_2 removal, one before and

one after methanation. The most important step is H_2S removal. The final product must be H_2S -free, the methanation catalyst must be protected from poisoning, and the CO_2 off-gas must have so little H_2S in it that it can be safely released to the atmosphere. Further, the H_2S removed must be concentrated enough for economical conversion in a Claus plant.

A typical flowscheme for gas purification is shown in Fig. 1. The composition of the feed to the H_2S absorber is:

H_2	-	46.	vol %
CO	-	15.	"
C_1	-	8.	"
CO_2	-	30.	"
H_2S	-	0.7	"

The ratio of CO_2 to H_2S is thus 43/1. H_2S must be removed to a high degree, at least to 4 ppmv (99.94% of that present in feed) to insure that the CO_2 off-gas will contain less than 20 ppmv. This must be done in the presence of a large excess of CO_2 , whose absorption must be suppressed in order to produce a sufficiently rich Claus gas,

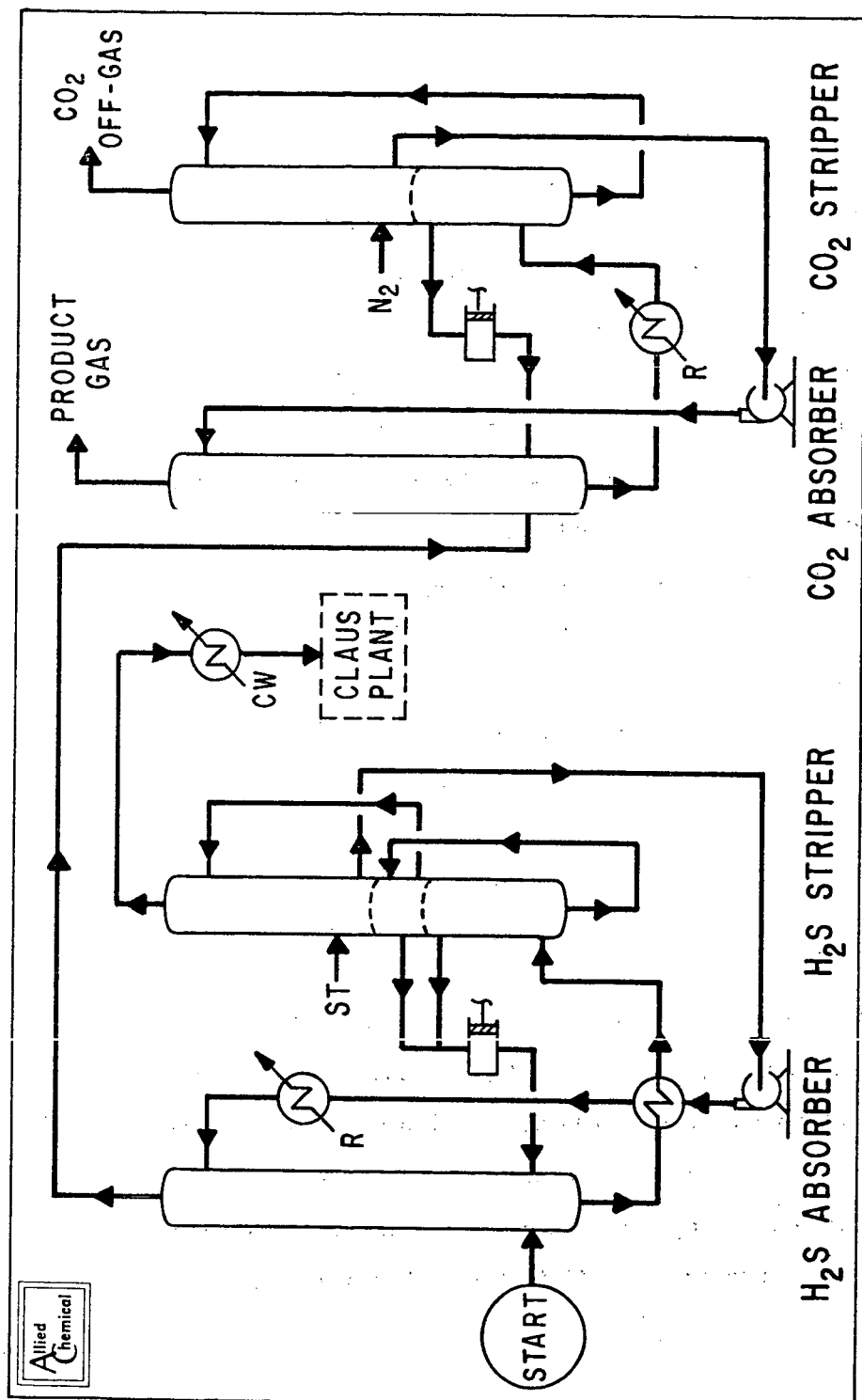


FIG. 1 SELEXOL™ PROCESS FLOW SCHEME FOR HIGH-BTU GAS FROM COAL GASIFICATION

something over 20% in H_2S .

This is done by first removing H_2S , using selective absorption and recycling some of the flashed gases.

Stripping is with steam, which can be condensed out of the Claus plant feed, giving a mixture of CO_2 and H_2S only. The Claus feed will contain more than 30% H_2S , a concentration well over that required for economical Claus processing.

In the flowscheme shown, only 4 - 4½% of the CO_2 present in feed will be absorbed in the H_2S removal system. This fraction can be varied by altering the number of stages in the absorber, the recycle rate, or the absorption temperature. Thus the costs of H_2S removal can be balanced against the costs of conversion in the Claus plant to bring down the overall costs to a minimum.

Gas leaving the H_2S removal section has essentially the same composition as that entering it, except that H_2S is at 4 ppmv. This gas passes to the CO_2 removal section, where the H_2S concentration will be further reduced to a few tenths of a ppm before methanation.

CO_2 can be removed both before and after methanation to suit any specification of methanator feed. Drying

of the final product to pipeline specification can also be arranged in a SELEXOL Process system, water leaving the system in stripping gas, which can be dry nitrogen coming from the air separation plant required to supply oxygen for gasification.

The CO₂ removal section is very simple. Besides the essential items of absorber, stripper, and pump, it has a flash tank and recycle compressor to keep methane losses very low, and a chiller to counter heat inputs from pumping and warm feed gases. CO₂ removal with SELEXOL Solvent is economical because most of the CO₂ is removed by simple flashing. Indeed, if CO₂ in the product could be 3.0%, regeneration could be by flashing alone. A lower CO₂ specification and a need for drying requires, however, that gas stripping be used.

Low-Btu Synthetic Gas

Another application which the SELEXOL Process seems to fit well is the purification of low-Btu fuel gases from coal. These gases, produced at intermediate pressures, are intended for turbine or boiler fuel. A typical gas from an air blown gasifier would have the following composition:

H ₂	-	15. vol %
N ₂	-	49. "
CO	-	22. "
C ₁	-	4. "
CO ₂	-	9. "
COS	-	.07 "
H ₂ S	-	.7 "

After sulfur removal, this gas is the fuel for gas turbines or boilers. It is important to note that in this example we have shown that COS is contained in the gas. All of the products from coal gasification we have seen have included COS as well as H₂S, in about a 1 to 10 proportion. Complete gas analyses have also shown lesser quantities of CS₂, mercaptans, thiophenes, HCN, aromatics, and olefins. These can all be removed by SELEXOL Solvent without decomposition of the solvent. the solubility of COS, however, lies between that of H₂S and CO₂, so that it is more difficult to produce a concentrate of COS than it is to produce a concentrate of H₂S. It can be successfully done, however, as this low-Btu gas example will show.

We have chosen severe requirements for treating this

gas. Total sulfur, including both H_2S and COS , is to be as close to 1 ppm as possible, while maintaining a Claus gas feed at 15% in total sulfur. The ratio between CO_2 and H_2S is 13 to 1, somewhat more favorable than that for high-Btu gas, but the presence of COS is a serious complication. COS does not harm SELEXOL Solvent and is absorbed by it, but its solubility is somewhat less than that for H_2S , which indicates that relatively higher circulation rates will be required. This will cause a greater absorption of CO_2 , leading to a less-rich Claus feed. In short, if COS becomes the key component, it will be more difficult to produce a satisfactory Claus feed, since the selectivity between COS and CO_2 is about half that between H_2S and CO_2 .

Nevertheless, it is possible to meet these requirements with an efficient absorber and some recycling. The simple flowscheme for this process is given in Fig. 2.

If the concentration of each solute can be 0.5 ppm, the degree of H_2S removal will be 99.9923%, and of COS removal, 99.23%. If COS is removed to the required degree, H_2S will be also, provided that stripping is good enough. Thus, absorption will be controlled by COS and stripping by H_2S . The stripping gas is steam, so that the Claus

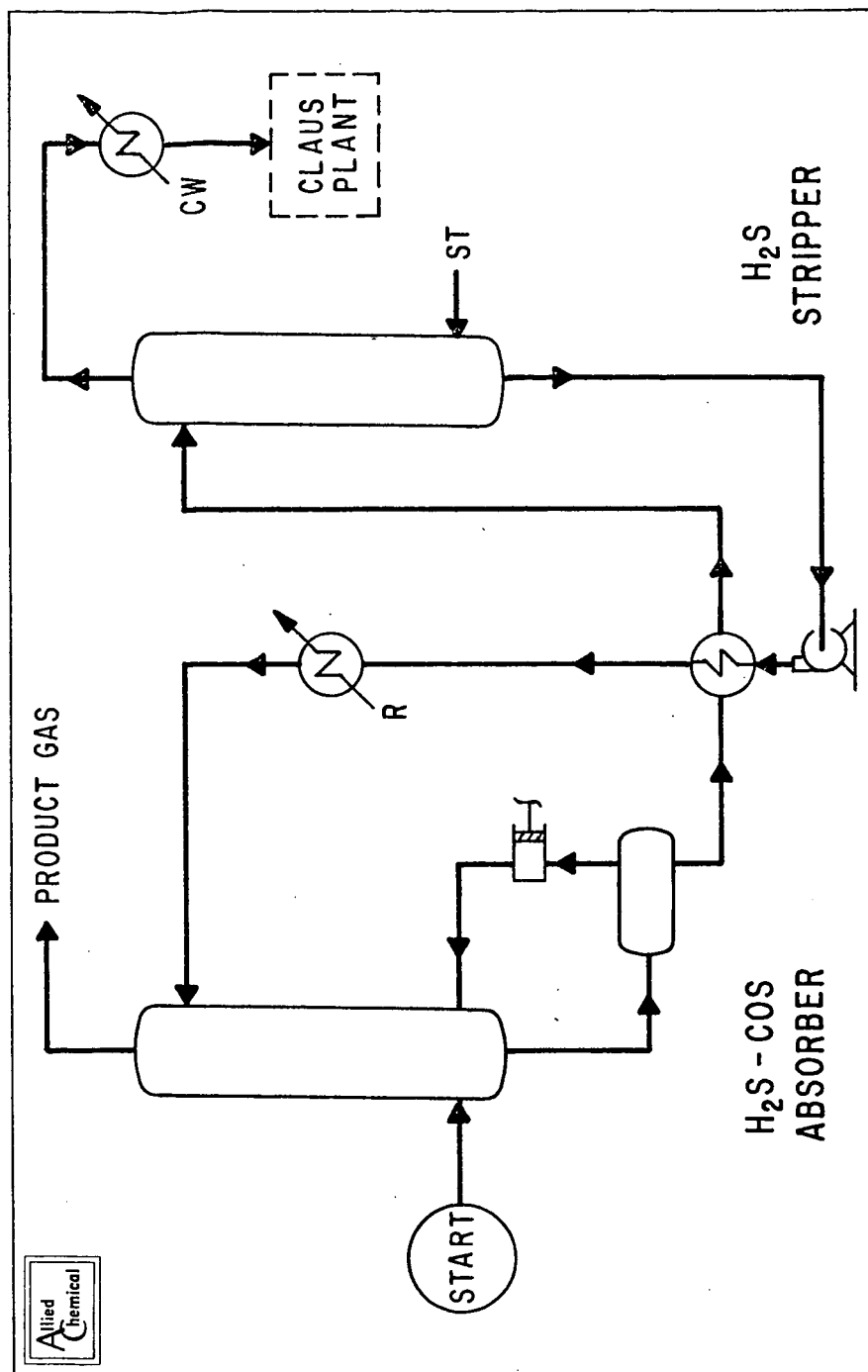


FIG. 2 SELEXOL™ PROCESS FLOW SCHEME FOR LOW-BTU GAS FROM COAL GASIFICATION

gas will consist only of H_2S , COS , and CO_2 . The H_2S - COS content will be over 15% but under 20% because of the lower selectivity between COS and CO_2 .

Conclusion

The trend of anti-pollution regulations governing synthetic fuel gas plants is toward conversion of almost all sulfur in feedstocks to elemental sulfur. The most reliable and economical conversion plant is the Claus plant, which does, however, need reasonably concentrated feeds for efficient operation. Because of high inherent selectivity for H_2S and COS over CO_2 , SELEXOL Solvent can successfully concentrate these sulfur compounds for Claus processing and yet remove them from products sufficiently to satisfy the most stringent requirements.

- - - - -

ACID GAS SEPARATION BY RECTISOL IN SNG PROCESSES

Gerhard Ranke, Linde A.G. 8023 Hoellriegelskreuth, new Munich, Germany
A. B. Munro, Lottebro Corporation

Economical acid gas removal plays an important part in the production of Substitute Natural Gas or of Low-BTU-Gas by coal gasification. Because the removal of H₂S, COS and CO₂ will be carried out under high pressure, a physical absorption process shows lower utility consumption figures and a lower solvent circulation rate than chemical absorption. Desulphurization is especially important. Air pollution standards require that the sulphur content (H₂S, SO₂) in the offgas be as low as possible. The extremely sulphur-sensitive Methanation Catalyst requires that all sulphur in the feedgas be removed down to the PPB-level. Sulphur compounds must be delivered to a Claus-unit at a concentration suitable for elemental-S removal.

Rectisol is most suitable for all these requirements; with a single solvent which is cheap, widely available, and non-corrosive, H₂S and COS are removed down to 1 ppm or, if required, to 0.1 ppm. Final purification of the gas with Zinc Oxide is then feasible. H₂S is concentrated to 20-30% in the H₂S-fraction. CO₂ can be removed to any desired level. The CO₂-offgas contains less than 5 ppm H₂S. CH₄ and H₂ losses can be reduced to less than 1% by means of a recycle compressor.

The process has been in commercial operation for several years for acid gas removal from the crude gas produced by the partial oxidation of residual oil, and meets the air pollution requirements for Los Angeles, California. Actual operating data are given for a plant with 80 NMSCFD throughput.

SYNTHETIC FUEL GAS PURIFICATION USING SHELL TREATING PROCESSES. E. J. Fisch,
C. J. Kuhre, 2525 Murworth, Houston, Texas 77054.

While fuel gas manufacture may initially be based upon gasification of lighter petroleum fractions which are essentially free of sulfur and other impurities, the energy supply industry will eventually turn to gasification of heavier raw materials, coal and crude oil. These materials however, will require more intensive processing, not only because of their lower hydrogen-to-carbon content ratios, but because of their higher contents of impurities, particularly sulfur. Because of society's unwillingness to tolerate even the present level of sulfur emissions, the application of gasification processes to these raw materials will require attendant means of removing the sulfur to acceptable levels in all product streams. Present technology does not offer economical means to adequately desulfurize coal or crude oil prior to gasification. Therefore, sulfur removal will most likely be effected by treating of intermediate or product gas streams. Three gas treating processes developed by Shell for general application for sulfur removal are applicable at one or more points in the manufacture of fuel gases. These are the SULFINOL, ADIP, and SCOT processes. The application of these processes is illustrated by cases for the production of (a) 1000 Btu per cubic foot substitute natural gas, (b) 400-500 Btu per cubic foot gas generated from coal for transportation to power generation units, and (c) 150 Btu per cubic foot gas from crude oil (residue) or coal for power generation via a combined gas/steam turbine cycle.